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(54) LIGHT SOURCE OF OPTICAL READER
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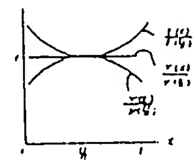

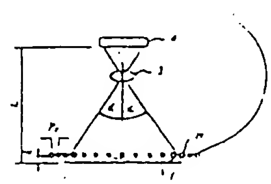

PURPOSE: To make approximately equal the outputs of photoelectric conversion systems including lens when they scan the manuscript surface of the same reflection factor by arraying plural spot form light sources to form an equivalent linear light source and individially setting the conditions of each spot form light source.

CONSTITUTION: An equivalent linear light source is formed by spot-symmetrically arraying plural light emitting diodes (LED) 20, 20 . . . on the line along the scanning direction being a height h from a manuscript surface 1, in such a way that pitches P_x become denser toward the end part from the central part. If the luminous intensity of each LED20 is constant, the illuminance E_x on the manuscript surface 1 is higher at both end parts and its characteristics in the relation with the illuminance E ($\ell/2$) at the central part qualitatively becomes like the illustrated curves, thus even if the characteristics of the photoelectric conversion system composed of a lens 3 and a photo transducer 4 are the similar to those of ordinary ones, it becomes possible to make its outputs V_x uniform in the relation with V ($\ell/2$). The same also applies even if the pitches of the LEDs are made constant, the height h is varied and the luminous intensity of each LED is varied.

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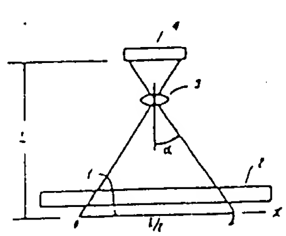

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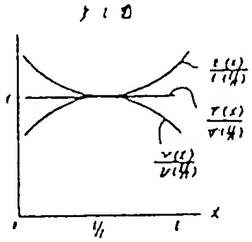

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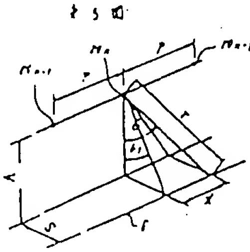

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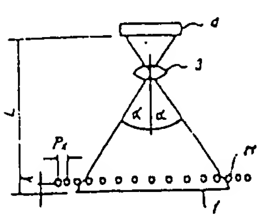

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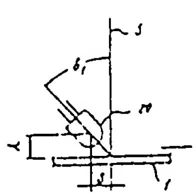

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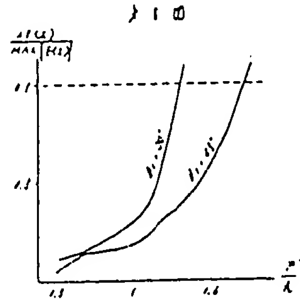

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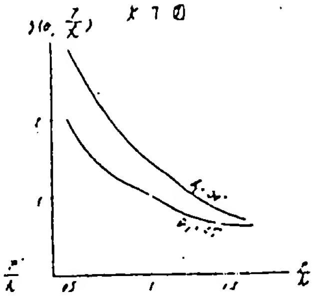

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Japanese Patent Laid-Open No. 76047/1978

1. Title of the Invention

Light Source for Optical Reader

2. Claims

1. A light source for use in an optical reader, comprising:

a photoelectric conversion system including a lens; and

at least one array of point sources of light for illuminating and scanning a document surface in a direction, light reflected from the document surface being received by the photoelectric conversion system,

at least one of the height of the point sources above the document surface, the distance by which the spot sources are spaced from each other, and the luminous intensity of the spot sources being varied in such a way that the ratio of the distance by which the spot sources are spaced from each other to the height lies within a given range, and that the level of the output from the photoelectric conversion system is maintained substantially constant while the document surface having a uniform reflectivity is being scanned in said direction.

2. A light source for use in an optical reader as set forth in claim 1, wherein the relation

$$P / h \leq 1.7$$

is satisfied, where P is the distance by which the spot sources are

spaced from each other, and h is the height of the spot sources above the document surface.

3. A light source for use in an optical reader as set forth in claim 1, wherein each of the spot sources of light is a light-emitting diode.

3. Detailed Description of the Invention

The present invention relates to a light source that is for use in an optical reader and consists of an array of spot sources of light which forms an equivalently linear source of light and permits the distribution of the illuminance created on a document surface by the linear source of light to be set at will.

An optical reader of the flat surface scanning type is schematically shown in Fig. 1. The reader comprises a light source 2 which illuminates a document surface 1. Light reflected from it is passed through a lens 3 onto a photoelectric device 4 as consisting of an array of photodiodes. The light source 2 is a linear light source, and generally made of a fluorescent lamp. Therefore, the light amount decreases at its both ends. To avoid the effects of this decrease in the light amount, the length of the lamp is selected to be sufficiently longer than the length ℓ of the scanned line. Let one end of a line on the document surface 1 to be scanned be located at the origin (0). Also, let x be the coordinate of a position on the document surface 1. It is said that the

distribution E(x) of the illuminance on the document surface 1 formed by the light source 2 satisfies the relations

$$0.9 < \frac{E(x)}{E(\ell/2)} < 1.1$$

then no practical problems take place.

Even if the illuminance E(x) is uniform within the lateral extent ℓ, the lens 3 reduces the marginal light amount substantially in proportion to $\cos^4 \alpha$, where α is half of the solid angle of the lens 3. Therefore, the ratio of the output V(x) from the photoelectric device 4 to $V(\ell/2)$ shows a characteristic as shown in Fig. 2. As can be seen from this graph, the level drops at both ends of the scanned line having the length ℓ. Generally, if the illuminance E(x) is constant independent of x, then it is desired that the relationships

$$0.95 < \frac{V(x)}{V(\ell/2)} < 1.05$$

be met. This means that every image on the document surface 1 having the same reflectivity does not change with x but must be converted into the same level, i.e., either black or white, within an allowance of about ± 10%.

Considering the foregoing, various attempts have been heretofore made to render $V(x)/V(\ell/2)$ constant. One example of these methods reduces the half solid angle α of the lens 3. Let ℓ

be 216 mm, the focal length f of the lens 3 be 15 mm, and the magnification m be 0.1. Then

$$\alpha = \tan^{-1} \frac{(\ell/2)}{\{(1 + m)/m\} f} \fallingdotseq 33^{\circ}$$

Since $V(0)/V(\ell/2) \fallingdotseq 0.5$, this is not practical. However, if $f = 42.2$ mm, then $\alpha \fallingdotseq 13.1^{\circ}$. In this case, $V(0)/V(\ell/2) \fallingdotseq 0.90$. This means that the optical reader operates but the distance L between the document surface 1 and the photoelectric device 4 is as long as about 510 mm. As a result, the size of the apparatus increases to an impractical extent.

Another known method of making light reflected and transmitted through the lens 3 uniform over the whole length of the scanned line consists in disposing a light-blocking plate in the optical path to reduce the light amount of the central portion of the reflected light incident upon the photoelectric device 4. Since the energy from the light source 2 is limited, the efficiency is not high.

Where a fluorescent lamp is used as the linear light source in each of the aforementioned apparatuses, the lightening device etc. make the apparatus bulky. The distribution of the illuminance on the document surface 1 due to the linear light source such as a fluorescent lamp is fixed. For this reason, if the arrayed elements of the photoelectric device 4 vary in transfer efficiency, it is impossible to compensate for this variance by any of the above-

described methods.

In view of the foregoing the present invention has been made. A light source which is built in accordance with the invention and which is for use in an optical reader comprises dot sources of light arrayed to form an equivalently linear source of light. The dot sources are so set up that the level of the output from a photoelectric conversion system including a lens is substantially uniform throughout the scan of the document surface having a uniform reflectivity.

One example of the invention is hereinafter described by referring to the drawings. Referring to Fig. 3, a plurality of light-emitting diodes (LEDs) 20 are arrayed along lines to be scanned. The diodes are placed at a height of h above a document surface 1. The diodes are arrayed about the center in such a way that the intervals P_x between them decrease toward either end. Thus, an equivalently linear source of light is formed.

It is assumed that every LED 20 has a constant luminous intensity. In this arrangement, the illuminance on the document surface 1 increases toward either end. The illuminance at the center is given by E (ℓ/2). The characteristic of the illuminance is represented qualitatively as shown in Fig. 2. The optical reader includes a photoelectric conversion system comprising a lens 3 and a photoelectric device 4. This conversion system is similar in characteristic to the conventional photoelectric conversion system.

The ratio of the output V (x) to V (ℓ/2) can be made constant as shown in Fig. 2.

This condition can be attained by spacing the LEDs 20 from each other by a given distance P and making the height h nonuniform, i.e., the diodes closer to either end are placed closer to the document surface 1. Alternatively, driving currents supplied to the LEDs 20 are so controlled that the luminous intensity differ from one LED to another. Thus, at least one of these alterable factors is easily changed to obtain a desired illuminance distribution.

The light source according to the invention consists of an array of spot sources of light, or discontinuous sources, to form an equivalently linear source of light. The characteristic shown in Fig. 2 is obtained by plotting the average value, for example, of the illuminances of the spot sources. That is, Fig. 2 shows only the general tendency of the illuminance distribution; the illuminance distribution contains pulsating components. If these pulsating components are large, then the light source are inadequate. A method of suppressing the pulsating components within a practically acceptable range is described next.

Fig. 4 is an enlarged side elevation of one LED 20. The LED 20 illuminating the document surface 1 is inclined at a given angle of θ_1 to an optical axis 5 so as not to impede the reading operation of the photoelectric device 4. Therefore, as shown in Fig. 5, the n-th LED 20_n is located at a distance of S and at a

height of h above a scanned line 6 which is illuminated obliquely accordingly. Let $e_n(x)$ be the contribution of the n-th LED 20_n to the illuminance distribution on the scanned line 6. The illuminance distribution E(x) due to the N LEDs is given by

$$E(x) = \sum_{n=1}^{N} e_n(x)$$

where $nP \leqq x \leqq (n+1)P$. E(x) assumes a maximum value of MAX{E (x)} and a minimum value of MIN{E (x)}. The difference between them is given by

$$\Delta E(x) = \mathrm{MAX}\{E(x)\} - \mathrm{MIN}\{E(x)\}$$

By normalizing this difference by MAX{E (x)}, it becomes a function of θ_1 and P/h, i.e.,

$$\frac{\Delta E(x)}{\mathrm{MAX}\{E(x)\}} = F(\theta_1, P/h)$$

In order to suppress this pulsating component to a practically acceptable level, the relation

$$F\,|\,(\theta_1, P/h)\,| < 0.1$$

must be satisfied.

In Fig. 6, ΔE(x)/MAX{E(x)} is plotted against P/h, where θ_1 is a parameter. Because of the above condition, either the relation $P/h < 1.3$ at $\theta_1 = 30°$ or the relation $P/h < 1.7$ at $\theta_1 = 45°$ must be met.

Where $\theta_1 = 45°$, at least one of P, h, and the luminous

intensity is varied while fulfilling the relation $P/h < 1.7$ to create a desired illuminance distribution. The output from the photoelectric conversion system utilizing this light source is maintained substantially constant as viewed either as a whole or minutely when it receives light from a document surface of a uniform reflectivity.

We now express the above example quantitatively. The illuminance distribution E (x) can be given by

$$E(x) = \frac{I}{h^2} g(\theta_1, P/h)$$

where I is the luminous intensity of each LED 20. Fig. 7 shows measured values of $g(\theta_1, P/h)$, where θ_1 is a parameter. From this figure, at $\theta_1 = 45^\circ$ the relation $g(\theta_1 = 45^\circ, P/h = 0.75) \fallingdotseq 2g(\theta_1 = 45^\circ, P/h = 1.5)$ is derived. At $\theta_1 = 30^\circ$, the relationship $g(\theta_1 = 30^\circ, P/h = 0.7) \fallingdotseq 2g(\theta_1 = 30^\circ, P/h = 1.3)$ is introduced. By making the height h constant and varying the interval P within an acceptable range, a light source whose illuminance distribution is given by $E(0)/E(\ell/2) = 2$ can be disposed opposite to the photoelectric conversion system given by $V(0)/V(\ell/2) = 0.5$ in the same way as the known apparatus already described. Hence, it is easy to make V(x) constant. In the above example, only a decrease in the light amount in the surroundings of the lens 3 is assumed. The inequality in transfer efficiency or sensitivity between the elements of the photoelectric device 4 can also be compensated for

by appropriately selecting the conditions of the LEDs.

As described thus far, the present invention provides a light source which is for use in an optical reader and which makes the output from the photoelectric conversion system constant during substantially the whole scan of a document surface of a uniform reflectivity irrespective of the characteristics of the photoelectric conversion system including the lens.

It is to be understood that the present example is not limited to the above examples but rather various changes and modifications are possible. For instance, each spot source of light may be a small-sized incandescent lamp.

4. Brief Description of the Drawings

Fig. 1 is a schematic of a conventional optical reader using a fluorescent lamp as its light source;

Fig. 2 is a graph showing the output characteristic of the optical reader shown in Fig. 1, as well as an illuminance distribution and an output characteristic obtained in accordance with the invention;

Fig. 3 is a schematic of one example of the invention;

Fig. 4 is a fragmentary, enlarged side elevation of the configuration shown in Fig. 3;

Fig. 5 is a fragmentary, enlarged, schematic perspective view of the configuration shown in Fig. 3;

Fig. 6 is a graph in which actually measured illuminance distributions are partially shown; and

Fig. 7 is a graph in which actually measured illuminance distributions are totally shown.

1: document surface;

3: lens;

4: photoelectric device;

5: optical axis;

6: scanned line;

20, 20_{n-1}, 20_n, 20_{n+1}: light-emitting diodes

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